BNFL Inc.

Section 2.3

Electrical Systems

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2.3.1. Electrical Power

2.3.1.1. Purpose

The purpose of the electrical power supply system is to provide power to the motor drivers, heaters, lighting, control and monitoring systems, mechanical handling equipment, and other miscellaneous electrical loads within the TWRS facility. Figure 2.3-1 is a simplified one line diagram of the electrical system.

2.3.2. Off-Site Power

Offsite power is provided from the DOE-furnished substation next to the TWRS-P facility. Power is supplied through two power transformers (in the substation), from two independent 230 kV transmission lines, one from Substation 251W (A8) and another from BPA Ashe Tap Switch Station (A22). The transformers deliver a 13.8 kV secondary voltage for the TWRS-P facility internal distribution. The TWRS-P facility loads are divided into two load groups, A and B. In as much as each transformer will normally be supplying the load assigned to its own load group, it is intended that each transformer will have adequate rating to carry all plant loads (Load Groups A and B) to mitigate:

- A partial loss of power (one out of two off-site feeders down), or
- A single transformer or its feeder being rendered inoperable due to repair or maintenance.

Based on the records available for the last five-year period provided by the Utility, the 230kV grid has experienced less than one outage per year which ensures a highly reliable off-site source of power. Adequate power quality is ensured by requiring that the minimum voltage delivered to the facility be no less than 97.5% of nominal at all times. The overall facility power factor will be maintained at no less than 95%.

2.3.2.1. Normal/Alternate Power

The normal source of power is defined as that available from the power grid under the normal plant operating conditions. The alternate source is available during a loss of Normal power condition. With two power sources normally connected to their respective loads, each source can, depending on specific operating conditions, be utilized as either Normal or Alternate.

The normal power is distributed throughout the plant at the medium (13.8 kV and 4.16 kV) and low (480V and 208/120V) voltage levels. The transfer capability between the Normal and Alternate power supplies is provided on each voltage level except normal 208/120 V AC.

2.3.3. On-Site Power

2.3.3.1. 13.8 kV

The 13.8 kV supplies are configured as the Normal and Alternate sources. Two 13.8 kV switchgear cabinets are installed in the Main Electrical Room in the Service Building and supply separate buses. Each bus supplies independent loads groups, designated as load group A and B. Under normal plant operating conditions, these buses are fed from their designated normal source. The buses are configured, however, to enable their transfer to an Alternate source through an inter-tie circuit breaker. This is possible by means of a double-ended bus configuration. Each end is normally connected to either Load Group A or B power supply and is rated to carry the entire plant load comprised of both load groups. The inter-tie circuit breaker or “tie-breaker” that connects these buses is normally open. The two bus feeder breakers and the “tie breaker” are interlocked such that only two of the three breakers can be closed at any given time. These interlocks prevent closing the “tie-breaker” if both feeder breakers are closed.

2.3.3.2. 4.16 kV

The 4.16 kV voltage level is dictated by specific requirements for the loads in the range above 250 HP (187 kW) and up to 1000 HP (746 kW). This voltage is derived from two separate power transformers (Load Groups A and B) installed outdoors and sized to carry all motor loads in the horsepower range indicated above. The power distribution is provided from the 4.16 kV switchgear located in the Main Electrical Room in the Service Building.

Similar to the arrangement discussed above for the 13.8 kV bus, the 4.16 kV buses are also separated into two load groups, A and B, with each bus rated for the entire load.

In addition to the motor loads indicated above, this voltage level is also used in the Low Activity Waste (LAW) melter power train. Two power transformers are provided to step down the 13.8 kV power to 4.16 kV. The 4.16 kV power will feed the LAW melter electrodes through voltage adjustment equipment.

2.3.3.3. 480 Volt Switchgear Power

There are two 480V load centers (serving load groups A & B) each having a 13.8 to 0.48 kV step down transformer providing power to the 480 V bus. The two 480 V load centers supply separate (load groups A & B) sets of equipment and therefore receive power from separate 13.8 kV switchgear buses. A normally open bus “tie breaker” can electrically connect the two sets of 480 V load center buses together. This feature enables taking either 13.8 kV switchgear breaker out of service for repair or maintenance as well as coping with a partial loss of 13.8 kV power by either load group. Each of the 480V switchgear is sized to concurrently carry load groups A and B operating loads.

2.3.3.4. 480 Volt Motor Control Center Power

As discussed above, the 480 volt motor control centers (MCC) receive their power from the 480 volt load center located in the Pretreatment building. There are up to three MCCs powered from each 480 volt load center, which will supply their load group, A or B. The 480 volt motor control centers distribute power to the medium and small size 480 volt motors, 480 volt heaters, 240/120-volt power panels, and lighting panels. Selected 480 volt motor control centers will be provided with an alternate power supply through automatic transfer switches fed from a 480 volt emergency power system. These motor control centers will provide power to the Important-To-Safety (ITS) equipment (identified in other sections of this document).

2.3.3.5. Emergency Diesel Generator and Support Systems

For the purpose of this description, the definition of an emergency power system is based on the definition contained in IEEE Std 100, IEEE Standard Dictionary of Electrical and Electronics Terms.

The BNFL experience has not required emergency diesel generators. BNFL has designed their Sellafield facilities with provisions for connection of portable power generators should facility power sources be lost for a significant period of time. This is based on extremely reliable power sources and the lack of an immediate need for an alternate power source.

For TWRS-P, it is anticipated that one permanently installed diesel generator will be provided to supply 480 Volt AC power to Important to Safety (ITS) systems or components on loss of off-site power. The project processes, particularly the 0004 Process and the Hazard Analyses, will confirm the need for such an emergency diesel generator, whether redundancy is required, whether the single failure criterion applies, and what the appropriate design codes will be. BNFL experience to date has not identified any hazard to which an automatic start (on loss of off-site power) requirement has been the necessary control strategy.

For purposes of this report, the assumed requirement is for essential electrical loads to be supported by a single emergency diesel generator set. This emergency generator will start automatically upon sensing loss of 13.8 kV bus voltage and assume the essential loads in a short time frame (to be determined by needs analyses). The emergency generator set will be housed in a self-contained enclosure. The enclosure will have appropriate environmental control equipment (heating and ventilation) to maintain the diesel generators within their operating envelope before and during required operation.

The need for seismic analysis or testing to demonstrate the capability of the emergency generator to function after the design basis earthquake has not been identified at this stage of design. if the 0004 Process or the Hazard Analyses identify a requirement for seismic qualification of the emergency diesel generator, analysis and/or testing of the diesel generator set and its auxiliary systems will be employed to demonstrate functionality following a seismic design basis event.

Electrical components initiating the start signals will be ITS components. A portion of the starting air system (air receiver and solenoids) will be ITS. The required (during operation) enclosure ventilation/cooling elements and the fuel oil system to the extent required (day tank, fuel oil transfer pump, and fuel oil storage tank) will be ITS. Engine lube oil heating and circulation for the pre-operation period may be provided subject to design analysis. The engine’s lube oil system is expected to be an integral part of the diesel as is its own cooling water pump. The source(s) of undervoltage sensing relay power, starting air solenoid power, and generator breaker control power will be ITS.

The applicable electrical codes and standards may conform to commercial standards or tailored IEEE 1E standards as determined by other safety analyses. At this time, commercial standards are the design basis pending results of other safety analyses.

It is not anticipated that sequential diesel loading will be required. Normal engine protection functions will remain operable (overspeed, high temperature, low oil pressure, shutdown, etc.) and are not ITS DSFs.

For investment protection purposes only and separate from the ITS emergency diesel generator, it is anticipated that additional on site electrical generation will be provided to supply backup power to the melters in the event of extended loss of off-site power. For clarity, this on site generation and supply system(s) is identified as standby power system(s) in keeping with the definition of standby power as included in IEEE Std 446, IEEE Recommended Practice for Emergency and Standby Power Systems for Industrial and Commercial Applications. Commercial grade support systems will be provided for diesel operation. Manual start is anticipated.

2.3.3.6. Uninterruptible Power Supply

Loads that must be provided a continuous source of electric power with no interruption are powered by a battery backed Uninterruptible Power Supply (UPS). The UPS delivers 120 volt vital AC, high integrity power. Normally, the UPS is powered from a 480 volt AC bus backed up by a emergency power system.

Each UPS will include battery charger, batteries with a specified capacity at rated UPS load plus factors for inverter inefficiencies, an inverter for converting DC to AC, a bypass transformer, static transfer switch, maintenance bypass switch, synchronizing circuitry and associated displays, alarms and data reporting and diagnostics functions.

When AC power is unavailable, the safety functions of the UPS loads is not affected by the loss of power as the UPS loads will be powered via the UPS inverters from the UPS or station DC batteries. In as much as the incoming power supply to the UPS is provided from a bus backed by the emergency power system, the AC power to the UPS can be restored within the time limits established for the emergency generator to automatically start and pick up loads.

In the event UPS components fail or the UPS is taken out of service, the UPS loads can be powered from an alternate source of power via a bypass switch.

The UPS system includes a static inverter, AC static transfer switch, a hardwired maintenance bypass switch, distribution panels, and a voltage regulating transformer as a bypass alternate source of power.

The UPS loads generally are limited to instrumentation and control loads sensitive to power interruption and emergency lighting, but may include other loads/systems as deemed necessary. Some UPS loads, such as the main integrated control system, will include provisions for redundant power supplies. For this system, two separate UPS systems may be used to improve availability. The UPS loads include, but are not limited to, the following:

1. Main integrated control system (not an ITS SSC)
2. Melter control system (not an ITS SSC)
3. Radiological surveillance system
4. Intercom system (not an ITS SSC)
5. Stack discharge monitor
6. Effluent discharge monitor
7. Area gamma monitor
8. Alpha/beta-in-air monitor
9. Public address and evacuation system
10. Waste tracking system (not an ITS SSC)

2.3.3.7. DC Power

The 125 volts DC power is available from two independent battery systems (assigned to Load Groups A and B) that are maintained on a continuous float charge by a dedicated charger/rectifier. This charger/rectifier also supplies the 125 volt DC loads during normal operation and during loss of normal power when an emergency power system is available. The charger is rated to carry all loads while charging the battery.

2.3.3.8. Cable, Raceway and Circuits

2.3.3.8.1. Circuit Grouping

Cable raceways are arranged physically, from top to bottom, in accordance with the function and voltage class of the cables, as follows:

1. 15 kV cables
2. 5 kV cables
3. Low voltage power AC and DC cables
4. High-level signal and control cables (120 VAC, 125 VDC)
5. Cables for low-level analog and digital signals.

In order to minimize the potential for electromagnetic interference, the instrument cables carrying low-level analog and digital signals are, to the extent practicable, routed in separate vertical stacks from the 15-kV and 5-kV cables.

A raceway designated for a single class of cable contains only cables of the same class. Cable trays containing low voltage instrumentation cables provide protection against spurious signal sources.

2.3.4. Lighting

The Lighting System is subdivided into the Normal and Emergency Lighting systems. The Emergency System is further subdivided into the Egress, Emergency Escape, and Essential Lighting Systems.

2.3.4.1. Egress Lighting

The Egress Lighting is achieved by means of self-contained dry battery packs/inverters integral to each lighting fixture identified as egress lighting. These fixtures are used for stairways and exit routes and remain available at all times.

2.3.4.2. Essential Lighting

A selected part of the normal lighting operates as essential lighting designed to provide a minimum level of illumination throughout the facility to aid in restoring the facility to normal operation or to aid in safe shutdown. This lighting is powered from a bus backed up by the emergency supply system identified as Important-to-Safety.

2.3.4.3. Emergency Lighting

The emergency lighting power supply is backed up by an uninterruptible power supply system. The lighting fixtures are separate from the normal lighting fixtures. Emergency lighting fixtures are used in areas, such as the main control room, which are required to sustain the minimum illumination level at all times, including a temporary loss of power.

2.3.5. Grounding System

A ground grid is furnished over the entire plant area to provide for personnel safety and equipment safety grounding. The grounding conductors will be of sufficient size to carry the maximum ground fault current. The grounding grid will be designed to limit touch and step potentials to safe values under the calculated ground fault conditions.

The system will utilize the features described in the following sections.

2.3.5.1. 13.8 kV System

This system is grounded through a grounding resistor derived at a zig-zag transformer at each power feeder provided by DOE/Utility. The rating of this resistor is selected to limit damaging ground fault current to a value adequate for relay operation (low resistance grounding). The described grounding system is based on the delta-connected secondaries of the DOE/Utility-furnished 230 - 13.8 kV power transformers. Some other transformer secondary winding configuration, if selected, will require a different grounding system (e.g., resistor-grounded system for a delta-wye transformer).

2.3.5.2. 4.16 kV System, Except for Melters

This system is grounded through a resistor to limit damaging ground fault currents to a value adequate for relay operation (low resistance grounding).

2.3.5.3. 4.16 kV for the Melters

The grounding system for the melters has not been determined at this point in design.

2.3.5.4. 480/277 Volts System

The neutral point is solidly grounded to the station ground grid.

2.3.5.5. 208/120 volts (including UPS)

The system neutral point is solidly grounded to the station ground grid.

2.3.5.6. 125 volts DC

These systems are ungrounded.

2.3.5.7. Analog Signal Grounds and Master Reference Grounds for Instrumentation

These grounds will be dependent upon the ground system(s) recommended or required by the Integrated Control System suppliers. Details will be developed with the selected suppliers.

2.3.6. Lightning and Surge Protection

Electrical equipment and lines are protected where necessary with lightning arresters and surge capacitors. In general, lightning arresters are installed where an overhead system changes to an underground system or at the equipment tied to the overhead lines. Lightning protection is installed for all buildings and high structures in accordance with the recommendations of the NFPA 780. The protection system consists of air terminals bussed together and connected to the facility grounding system via down conductors.

2.3.7. Heat Tracing and Freeze Protection

Electrical heat tracing (freeze protection) is provided for liquid-filled piping and instrument sensing lines routed outdoors that are subject to freezing. The system is operable when subjected to an outdoor temperature range of minus 30° F to plus 104° F.

The electrical heat tracing system is designated and fabricated for the following conditions:

- Heat tracing for freeze protection of piping systems based on sensing the ambient temperature
- Heat tracing for process heating of piping systems based on sensing the pipe temperature.

2.3.8. Cathodic Protection

The need for a cathodic protection system and its type will be determined in the detailed engineering phase depending on the site soil characteristics. The extent of protection will be based on the results of the site soils analysis and resistivity readings. Consideration will be given to protection of such plant structures as underground pipes and storage tanks, surface storage tank bottoms, etc. Permanent test stations will be provided at appropriate locations to periodically test the system.

2.3.9. Electrical System Design Safety Features

2.3.9.1. Important-to-Safety (ITS) Circuits

Electrical equipment, cable, and circuits identified as ITS are physically separated from other equipment, cables, and circuits to increase their availability during a common mode failure or a design basis event. A specific method of separation and minimum separation distances, if any, will be decided on during the detailed engineering phase.

2.3.9.2. Emergency Diesel Generator

Provides alternate power to Important to safety equipment, controls and instrumentation and has the following Design Safety Features:

1. Automatic Start on Loss of off-site power
2. Periodic Testing
3. Proven Technology
4. CCR Trouble Alarms

2.3.9.3. Distribution of Power from the Emergency Diesel Generator

The emergency Diesel generator and the distribution system for the loads connected to this system comprises the emergency power system. The electrical distribution system for this system delivers power to the Important to Safety equipment, controls, and monitoring instrumentation and has the following Design Safety Features:

1. Proven Technology
2. Fault Detection
3. Emergency Diesel generator output can be connected to either load group A or B
4. Faults would be revealed during normal operation

2.3.9.4. Uninterruptible Power Supply

Provide reliable power to alarm systems, Important To Safety monitoring and control circuitry, and the evacuation systems.

- Periodic testing
- Self Diagnostics
- Trouble alarm
- Proven technology
- Faults will be revealed during normal operation
- Static Transfer to alternate source

2.3.9.5. Emergency Lighting

Allows plant operators to activate and monitor important to safety equipment and devices and allow parts of building to be occupied safely upon event of airborne release of radiation. It has the following Design Safety Features

1. Periodic Testing
2. Proven Technology
3. Trouble Alarm.

2.3.9.6. Essential Lighting

Facilitate operator's monitoring functions for important to safety systems and has the following Design Safety Features:

1. Periodic Testing
2. Proven Technology
3. UPS Source for Selected Lighting Fixtures

2.3.9.7. Emergency Egress Lighting

Facilitate safe personnel egress in event of a loss of power to lighting systems.

1. Periodic Testing
2. Proven Technology
3. Batteries
4. Battery status alarm
5. Charging System

Figure 2.3-1. Electrical Distribution System

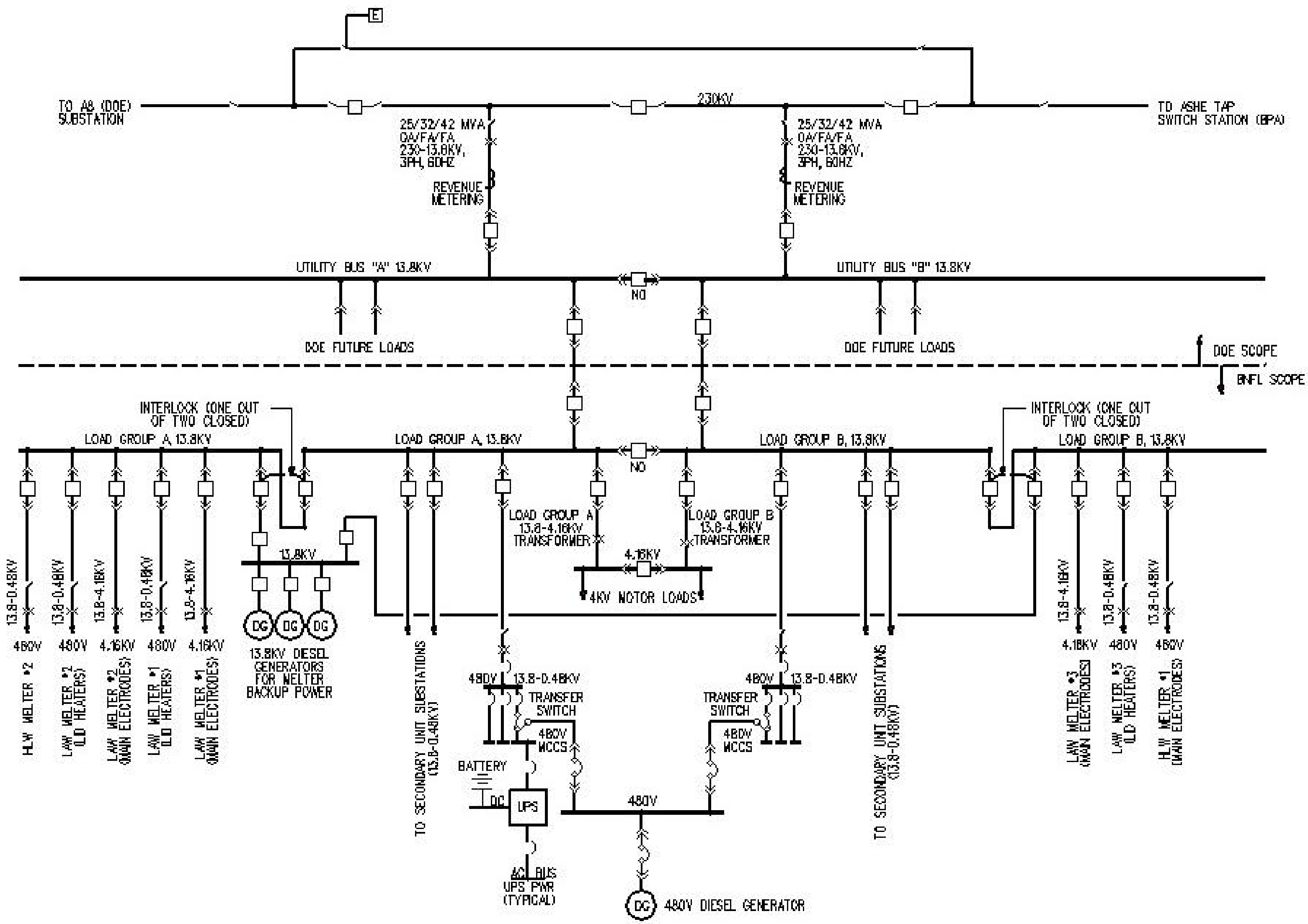

Table 2.3-1. Electrical Systems

Fault	Important to Safety SSCs	Safety Function	Design Safety Features
Loss of Normal and Alternate Power	On-site Emergency Diesel Generator with necessary support systems	Provide alternate power source for Important to safety equipment, controls and instrumentation	Automatic Start on Loss of off-site power Periodic Testing Proven Technology CCR Trouble Alarms
	On Site emergency 480 V distribution system	Distribute Power to Loads identified as Important to Safety	Generator Output is distributed to two separate load groups. Distribution faults will be revealed during normal operation. Proven Technology
Failure of Normal Lighting or loss of power to Normal Lighting system	Essential Lighting System	Allow plant operators to activate and monitor important to safety equipment and devices	Periodic Testing Proven Technology
	Emergency Power system	Allow parts of building to be occupied safely upon event of airborne release of radiation Provide power to selected lighting circuits on loss of normal or alternate power sources	Automatic Start on Loss of power Periodic Testing Proven Technology CCR Trouble Alarms
Loss of Normal Control Room Lighting or power source	UPS source for selected lighting fixtures	Facilitate operator's monitoring functions for important to safety systems	Periodic Testing Proven Technology Faults are revealed in normal operation Trouble Alarms
Failure of normal Lighting or power source	Emergency Egress Lighting System	Facilitate safe personnel egress in event of a loss of power to normal lighting systems.	Periodic Testing Proven Technology
	Batteries, Charging System	Provide power for emergency egress lighting.	Periodic Testing Proven Technology Battery status alarm

Table 2.3-1. Electrical Systems

Fault	Important to Safety SSCs	Safety Function	Design Safety Features
UPS component failure	Complete UPS systems including batteries	Provide reliable power to alarm systems, Important to Safety monitoring and control circuitry and the evacuation systems.	Periodic testing Self Diagnostics Proven technology Static Transfer to alternate source Faults are revealed in normal operation